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PROGRESS REPORT

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BATTLE MEMORIAL INSTITUTE

Jan 5 '53

SIXTH MONTHLY PROGRESS REPORT

on

A STUDY AND EVALUATION OF LIQUID-LEVEL AND LIQUID-VOLUME CONTROLS FOR SHELL-, ROCKET-, AND BOMB-FILLING MACHINES

to

ARMY CHEMICAL CENTER

December 31, 1952

Contract No. DA 18-108-^{CHP}~~CHL~~-3965

by

Thomas M. Boland, William Hecox,
Roger L. Merrill, and Robert C. McMaster

BATTELLE MEMORIAL INSTITUTE
505 King Avenue
Columbus 1, Ohio

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5 0 5 K I N G A V E N U E C O L U M B U S I , O H I O

January 2, 1953

Commanding Officer
Chemical Corps Chemical and Radiological Laboratories
Army Chemical Center, Maryland

Attention Mr. Curt Hesdoerffer
Project Officer

Dear Sir:

We are enclosing six copies of the Sixth Monthly Progress Report on "A Study and Evaluation of Liquid-Level and Liquid-Volume Controls for Shell-, Rocket-, and Bomb-Filling Machines", covering the period from December 1, 1952, to December 31, 1952.

Preliminary tests have been made on the basic liquid-volume filling device. A summary of the results of these tests is included in this report, together with suggested methods of improving the performance of this device.

Yours very truly,



Thomas M. Boland
Electrical Engineering Division

TMB/PL

Enc. (6)

R E S E A R C H F O R I N D U S T R Y

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December 31, 1952

SUMMARY

The basic construction of the filling system that weighs the desired amount of liquid in an intermediate chamber is completed, except for the automatic-sequencing control equipment. Initial tests have been made of this system, and overfilling results.

To remove this undesirable effect, modification of the servo system and valve-operating mechanism is necessary. Several such modifications are proposed in this report and are, or will be, effected.

INTRODUCTION

This is the Sixth Monthly Progress Report on "A Study and Evaluation of Liquid-Level and Liquid-Volume Controls for Shell-, Rocket-, and Bomb-Filling Machines". This report covers the period from December 1, 1952, to December 31, 1952.

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At the present time, the major effort of this research program is directed toward the development of a liquid-volume munition-filling device. A basic system that weighs out the desired volume of liquid agent is now being constructed at Battelle.

WORK IN PROGRESS

During December, the work consisted of three phases:

1. Completion of the basic prototype filling-system construction.
2. Initial tests of the basic system.
3. Consideration of modifications to improve the basic system performance.

Prototype Construction

Following the delivery of the Annin valve, the liquid-flow system to the weigh chamber was completed. As now constructed, this system is composed of a constant-level supply tank, a solenoid valve, and the Annin valve. Three desirable features of this system are these:

1. The constant-level supply tank provides a constant static head by the liquid on the Annin valve.
2. This static head may be increased or decreased easily by merely changing the level in the tank.
3. The solenoid valve provides protection against electrical power failure.

When delivered, the Annin valve was equipped with a standard hand-wheel operator. For the initial setup of the filling device, this was replaced so that the valve could be operated by the servomotor.

The valve differential transformer was mounted directly on the valve frame; the movable slug was fastened to the valve stem. This combination provides an output voltage proportional to the valve-port opening. The scale differential transformer was mounted so that its output is zero at balance, and is proportional to the amount of unbalance of the lever arm.

The Annin valve provides a 90 degree change in direction of the liquid flow. (See Figure 2, Third Monthly Progress Report.) This minimizes the possibility of the presence of liquid droplets on the valve parts. This valve is mounted directly above the weigh chamber. (See Figures 1 and 3, Fifth Monthly Progress Report.)

Initial Tests of the Basic System

Following the basic construction of the prototype, initial tests were run on the system. For these tests, the level in the supply tank was 16 inches above the Annin valve seat. A speed-reduction unit of 25-to-1 ratio was used to couple the servomotor to the valve.

For the first test, it was decided to attempt to fill 20 grams of water. The initial position of the valve was closed, and the scale was balanced. In testing, the 20-gram weight was placed on the counterweight pan. Then the servo amplifier was energized. The response of the system was, however, too slow and overflow resulted. The system was also tested for 50-gram and 250-gram liquid fills. The following are results of these tests:

<u>Counterweight, grams</u>	<u>Fill Weight, grams</u>
20	32.5
20	30.0
20	30.0
20	32.0
50	71.5
50	71.0
50	73.5
250	389.0
250	386.5
250	386.5

In analyzing these data, it is obvious that the servo-valve-system response is too slow. Specifically, the position of the valve does not follow the scale balance arm closely enough.

Several possible methods are suggested to overcome this fault:

1. Decrease the valve-port size. This will decrease the liquid-flow rate through the valve for a given per cent opening.
2. Decrease the gear ratio of the speed reducer coupling the servomotor to the valve. This will, however, reduce the torque applied to operate the valve. As the system is now constructed, nearly full torque is required of the servomotor to open or close the valve.

3. Apply an auxiliary spring to stiffen the scale for larger unbalance. This will permit more rapid response of the servo system until the region of balance is reached. Sensitivity at balance will not be affected by such a spring, so that accurate weight measurements will be assured.

The error of the repeatability of the system, even as now built, is not greater than 8 per cent. The overfill at 20-, 50-, and 250-gram counterweight is fairly constant, as is shown in the initial test results.

Filling-System Modification

On the basis of the preceding results, the following modifications are now being made:

1. Two sets of valve plugs and seats have been ordered from the Annin Company. The flow capacities of these two are $1/4$ and $1/10$ that of the $3/8$ -inch valve port now installed.
2. A number of spring-steel strips are being obtained for use as auxiliary springs on the scale.
3. Additional speed reducers of various ratios are on order.

It is hoped that by a combination of the above modifications, the system accuracy will be improved.

FUTURE WORK

Following the arrival of the additional parts for the valve control system, the work will be directed toward arriving at a combination of system parts which will eliminate overfilling. Also, control of the liquid flow is to be improved so that increased accuracy may be achieved.

An inspection of the present filling device by Army Chemical Center personnel is also planned during January.

TMB:WH:RLM:RCMcM/PL
December 29, 1952

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